Monitoring System Temperature and Humidity of Oyster Mushroom House Based On The Internet Of Things

Irma Saraswati
Electrical Engineering
University of Sultan Ageng Tirtayasa
Cilegon, Indonesia
irma.saraswati@untirta.ac.id

Adhitya Rahma Putra
Electrical Engineering
University of Sultan Ageng Tirtayasa
Cilegon, Indonesiay
adhityarahma@gmail.com

Masjudin
Electrical Engineering
University of Sultan Ageng Tirtayasa
Cilegon, Indonesia
masjudin@untirta.ac.id

Alimuddin
Electrical Engineering
University of Sultan Ageng Tirtayasa
Cilegon, Indonesia
alimuddin@untirta.ac.id

2022 International Conference on Informatics Electrical and Electronics (ICIEE) | 978-1-6654-8622-4/22/$31.00 ©2022 IEEE | DOI: 10.1109/ICIEE55596.2022.10010066

***Abstract*—Environmental aspects in oyster mushroom cultivation are things that must be considered, namely for optimal growth of oyster mushrooms and getting maximum yields. The optimal temperature for fruiting bodies is in the temperature range of 26 to 28°C and mycelium growth is at a temperature of 28 to 30°C, while the humidity required is 80 to 90%. Temperature and humidity are one of the main factors for the growth of oyster mushrooms. The DHT22 sensor is used to detect temperature and humidity. To make it easier to monitor temperature and humidity in an oyster mushroom house remotely and in real-time based on the internet of things, use ThingSpeak on the website and ThingView on smartphones. Based on this study for 14 days, environmental conditioning of mushroom house by misting or spraying water carried out 3 to 4 times a day proved to be less effective, because during the day the temperature and humidity were still outside the range of values required for optimal growth of oyster mushrooms. System test monitoring shows the system is working well and the output data results are displayed via the LCD, ThingSpeak on the website, and ThingView on a smartphone android.**

***Index Terms*—Oyster Mushroom, Internet Of Things, Temperature, Humidity**

I. Introduction

Indonesia is a country located in the tropics, so it has high biodiversity. One of the biodiversity is mushrooms [1]. Pleurotus sp or oyster mushroom is the most widely cultivated type of mushroom. Oyster mushrooms have a shorter cultivation period and lower financial costs for production [2]. The oyster mushroom is a type of wood mushroom that has a higher nutritional content than other types of wood mushrooms. Oyster mushrooms contain protein, fat, phosphorus, iron, thiamin, and riboflavin higher than other types of mushrooms. Oyster mushrooms contain 18 kinds of amino acids needed by the human body and do not contain cholesterol [3]. Oyster mushroom growth is highly dependent on physical factors such as temperature, humidity, light, pH of the growing media, and air aeration. Oyster mushrooms can produce mycelium and fruiting bodies optimally in a temperature range of 26°C – 30°C, with a humidity of 80 to 90% and a slightly acidic pH of the growing media between 5 - 6. Aeration is important for air exchange in the mushroom growing environment, namely by maintaining a supply of oxygen ($O2$) and removing carbon dioxide ($CO2$), the sunlight needed for fungal growth is very little, which is a maximum of 300 lux [4]. Lighting with different intensities also affects the growth of white oyster mushroom mycelium. During the mycelium formation phase that meets baglog, it does not need high light intensity or even does not need light at all, while the white oyster mushroom fruiting body formation phase requires a rather bright light intensity [5]. Mushroom cultivation farmers usually mist or spray-on oyster mushroom houses in the morning, afternoon, and evening every day, or as much as 3 to 4 times a day [6].

978-1-6654-8622-4/22/$31.00 ©2022 IEEE

Technological developments have penetrated various aspects of life that support the technological needs of society itself. Technology can develop widely because of the role of the internet network [7]. Along with the times and technological developments are increasingly rapid. People's need for electronic devices is now increasing, so there are so many devices with such innovative technology. These technologies can be in the form of automated systems or smart systems that do not require human supervision at all times, namely Android-based technology, wireless sensor networks, and the internet of things [8]. The Internet of Things is a concept that helps humans carry out various daily activities in monitoring and controlling sensors, LEDs, and electronic equipment remotely [9]. IoT is a smart network that connects all things to the internet to exchange information and communicate through information sensing devices according to agreed protocols [10]. The use of IoT has also penetrated various fields, such as engineering, administration, economics to agriculture, and animal husbandry [11]. One of the platforms for IoT is ThingSpeak, which is an open-source IoT platform for retrieving and storing data via the internet or via a local area network [12]. ThingSpeak receives data in real-time, data processing, and also simple visualization for its users. The important reason for choosing ThingSpeak is that it is open-source so we are free or free to use it and it is the easiest to use compared to platforms [13].

Previous research has been done discussing the method of watering oyster mushrooms [14]. Several studies of temperature and humidity have been based on IoT, but there is no monitoring of light intensity, as well as temperature and humidity sensors that still use the DHT11 sensor based on the datasheet, are less accurate than the DHT22 sensor [15] [16]. Other research is in the form of monitoring and controlling manually through the Ubidots application [17].

The purpose of this research is to produce a temperature and humidity monitoring system based on the Internet of Things, as well as to determine the misting or spraying system for the appropriate temperature and humidity values to produce optimal growth of oyster mushrooms. Based on previous studies, it is necessary to have a monitoring temperature and humidity in oyster mushroom house cultivation. The monitoring used is based on the internet of things. By using the internet network and can be accessed via smartphone android.

II. RESEARCH METHODS

A. A. Research Methods

Stages are shown in a flow chart that explains how the research and testing process is carried out. The description stages carried out in the study are described in Figure 1 below.

The explanation of the research flow chart in Figure 1 is as follows:

1) Problem Identification, identifying problems that occur in oyster mushroom house cultivation. From the existing problems, a theme is found to overcome the problem and then conduct research.
2) Literature study, researchers use references which can be in the form of research journals and books related to this research. In this case, it can be done by reading and taking theory from reference books, the internet, and other references related to the design of this tool.
3) Hardware and Software Design, the design is done with the help of software by designing a block diagram containing the components used
4) Hardware Assembling, hardware designing This is done by combining each component to become a unified system. The combination of these components starts from the smallest semiconductor components to large components such as modules and even microcontrollers.
5) Hardware and Software Testing, testing is carried out per hardware and software section as well as testing the entire system, in this case, to find out whether the tools made are running as needed or not, and whether there are errors or not. If the test is successful then perform data collection and analysis.
6) Data analysis, discussion, and analysis are needed to determine the research runs according to the design and results that work well and follow the objectives.
7) Conclusion, the final stage is to conclude the results of the research as a whole and write them down in a report.

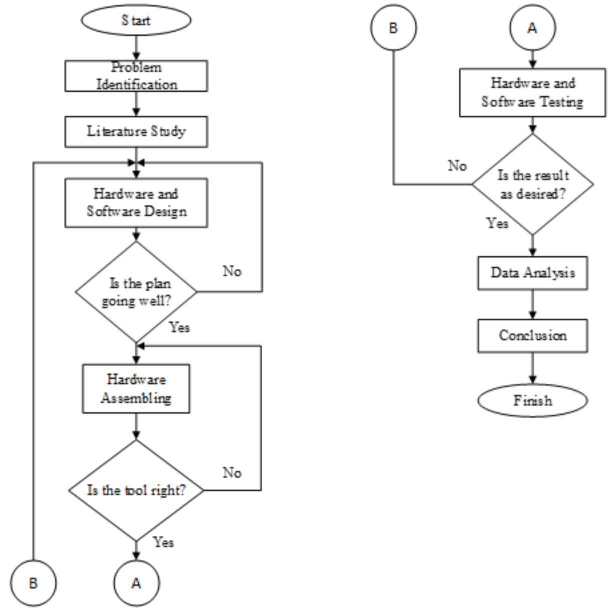

Fig. 1. Research Flowchart.

B. Tool Design for Oyster Mushroom House

The design of the tool for this oyster mushroom house was made with the software Sketchup. The design layout of the overall display following is a tool design for the oyster mushroom house which can be seen in Figure 2.

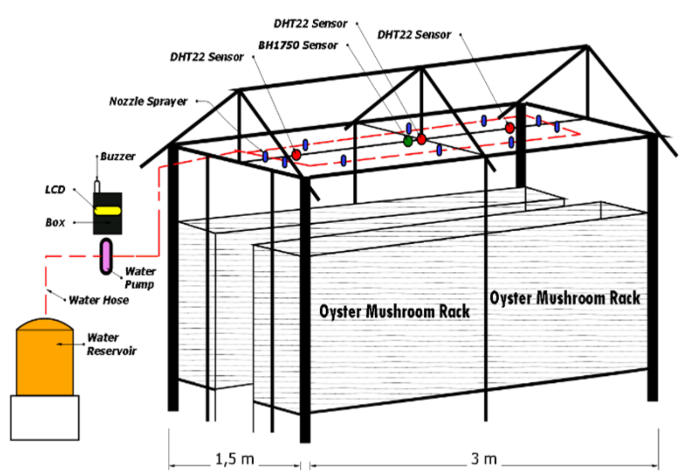

Fig. 2. Tool Designed For Oyster Mushroom House

Figure 2. is a tool designed for an oyster mushroom house. Oyster mushroom house measuring 3 meters long, 1.5 meters wide, and 3 meters high. There are 2 shelves with 4 levels each made of bamboo to store oyster mushrooms for a capacity of 350-400 baglogs in the oyster mushroom house. There are 3 DHT22 sensors, 1 BH1750 sensor, and 10 sprayer nozzles inside the mushroom house. The distance between the DHT22 sensors placed in the oyster mushroom house is 0.75 meters.

C. Circuit Tools

The design is carried out to determine the relationship between the microcontroller and the input and output components used. The overall toolkit of this study describes the pin relationships used between each component and other components.

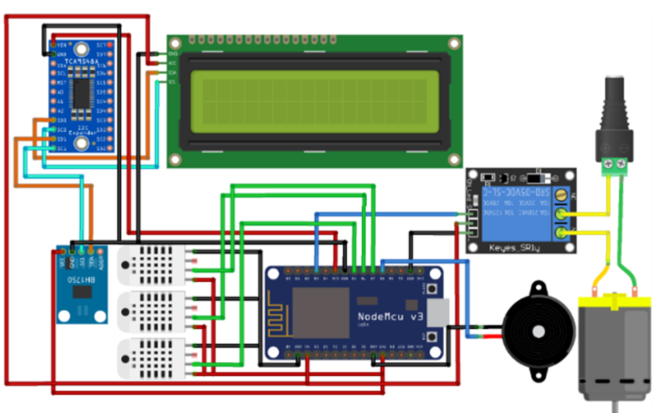

Fig. 3. Whole Set of Tools

Figure 3 is the overall tool circuit of this study which describes the pin relationships used between each component and other components. The following is an explanation of each component:

1) The DHT22 sensor is used for temperature and humidity in oyster mushroom house, temperature sensing range: -40° +80° Celsius (±0.5°C accuracy). The results of this sensor reading will later become a reference for determining the set point of the temperature and humidity that is given according to the needs of the oyster mushroom.
2) The NodeMCU ESP8266 microcontroller functions for sensor data processing and actuator control. NodeMCU also functions as a data sender that was previously connected to the internet which allows NodeMCU to transmit sensor reading data on ThingSpeak.
3) The relay is used as a switch to adjust the pump as an actuator according to setpoint a predetermined
4) The 20x4 LCD is used to directly see the temperature and humidity values that have been read by the sensor and on the oyster mushroom house.

D. Software

Design Software includes designs that support this research, namely ThingSpeak on the website and the ThingsView on smartphones. ThingSpeak on the website can be accessed via http://thingspeak.com. While ThingsView can be downloaded via the Play Store on Android.

Fig. 4. The ThingSpeak

III. RESULT AND DISCUSSION

A. Result Of Tool Design

This study discusses the monitoring of temperature and humidity based on the internet of things. System design monitoring on the oyster mushroom house can be seen in Figure 5.

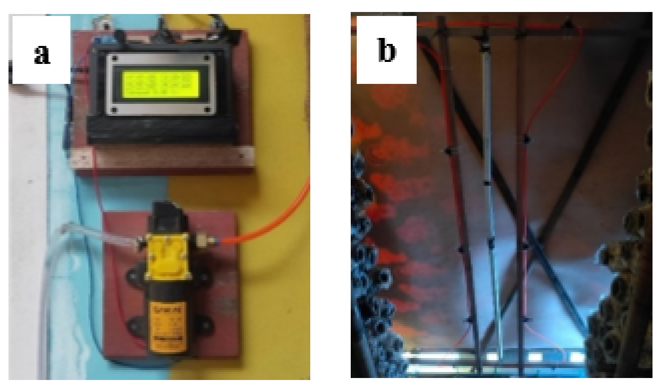

Fig. 5. (a) Component Box and Pump, (b) Sensor and Sprayer Nozzle

Figure 5. (a) is a display of the box, pump, sensor, and nozzle sprayer. system tool monitoring consists of a box containing a series of components and a pump that is placed outside the oyster mushroom house. Sensors and sprayer nozzles are placed inside the oyster mushroom house. In the box, the 20×4 I2C LCD module is placed in the middle position by protruding out with the aim that the results of monitoring the oyster mushroom house can be seen by the user. module buzzer is above the box assuming the user can hear the alarm sound loudly. The pump functions to regulate

temperature and humidity. NodeMCU ESP8266, TCA9548A, and relay are in the box to be safe and avoid the unexpected. Figure 5. (b) is the placement of the sensor and sprayer nozzle on the oyster mushroom house. 3 DHT22 sensors, 1 BH1750 sensor, and 10 sprayer nozzles are inside the oyster mushroom house and are placed at predetermined points.

B. ThingSpeak Test

In this study, namely ThingSpeak on the website and the ThingView application on smartphones. This test was conducted to determine the suitability of the data generated on ThingSpeak and ThingView. ThingSpeak test results can be seen in Figure 6. Figure 6 is a display of the results of the ThingSpeak test on the website. It can be concluded that the ThingSpeak test on the website went well. ThingSpeak can display graph results in real-time and the same results at one time from DHT22 sensor data. In addition, the data stored in the ThingSpeak database can be downloaded from the Export Recent Data or Export/Import from the ThingSpeak menu on the website.

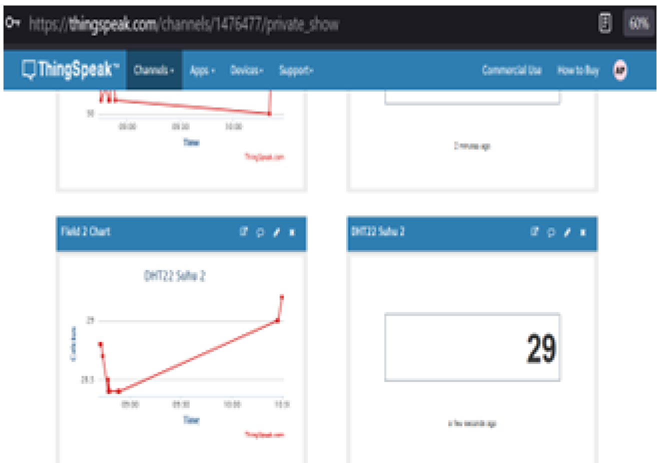

Fig. 6. ThingSpeak Test

C. ThingView Test

Figure 7 is a display of the results of testing the ThingView application on an android smartphone. Figure 7 is a display of the results of the ThingView test on android. It can be concluded that the testing of the ThingView application on the smartphone went well. For the ThingView application on smartphones, you can download it on the Play Store for free, then enter the API Key to access it. ThingView can display graph results in real-time and the same results at one time from the obtained DHT22 sensor data.

1) Testing Without Baglog On Oyster Mushroom House: Tests on the oyster mushroom house without baglog were carried out for 2 days, consisting of testing without treatment or without misting and testing with treatment or no misting which was carried out 3 to 4 times a day. This test was conducted to determine the differences and the effect of using the tool on various conditions in an oyster mushroom house.

Fig. 7. ThingView Test

Figure 8. is the result of observations made on the oyster mushroom house without treatment or without misting. The weather conditions on the first day were cloudy in the morning, light rain in the morning before noon, and sunny in the afternoon until the evening. Based on observations on the graph, the highest temperature is 31.7°C at 14.00, humidity is 70.7% at 16.00. The average temperature value for 24 hours is 28.9°C, while the average humidity for 24 hours is 79.8%. Figure 9. is the result of observations made on the oyster mushroom house by treatment or by misting. The weather conditions on the second day were sunny from morning to evening. Based on observations on the graph, the highest temperature is 31.7°C at 12.00, humidity is 69

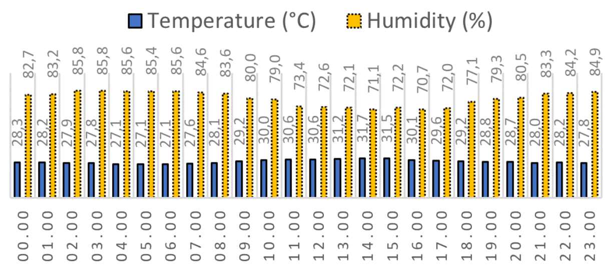

Fig. 8. Testing Without Baglog (Without Treatment)

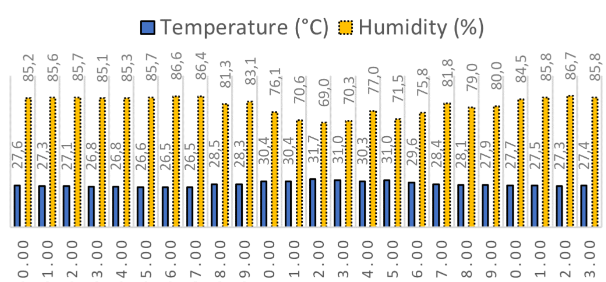

Fig. 9. Testing Without Baglog (With Treatment)

Based on observations made for 2 days there are differences. For the first day, the average temperature value for 24 hours is 28.9°C, and the average humidity for 24 hours is 79.8

D. E. Testing With Oyster Mushroom Baglog

Performance testing of the tool in this study was conducted to determine the effect of using the tool on various conditions in an oyster mushroom house. In this study, 200 samples of oyster mushroom baglog were used. Observations were made for 14 days to determine the effect of various weather conditions and the method of watering or misting on the temperature and humidity values in the oyster mushroom house. The method used is misting 3 to 4 times a day on the oyster mushroom house.

Based on the results of observations made on the oyster mushroom house on the first day, the weather conditions on the first day were rainy in the morning, cloudy in the morning before noon, rainy in the afternoon, rainy in the afternoon before late afternoon, cloudy in the afternoon and sunny at night. Based on observations on the graph, the highest temperature is 28.43°C at 12.00, humidity is 82.03% at 12.00. Based on the database on ThingSpeak, the lowest temperature value is 24.6°C detected from sensor 1 DHT22 at 05.00, the highest temperature value is 28.5°C detected from sensor 2 and sensor 3 DHT22 at 12.00. The humidity is 79% detected from sensor 1 DHT22 at 12.00, the humidity is 92.3% detected from sensor 3 DHT22 at 08.00.

On the second day, the weather conditions on the second day were sunny in the morning, rainy in the morning before noon, cloudy in the afternoon, cloudy in the afternoon before late afternoon, sunny in the afternoon, and sunny at night. Based on observations on the graph, the highest temperature is 29.6°C at 14.00, humidity is 77.4% at 14.00 and 15.00. Based on the database on ThingSpeak, the lowest temperature value is 24.6°C detected from sensor 1 DHT22 at 06.00, the highest temperature value is 31°C detected from sensor 1 DHT22 at 14.00. The humidity is 72% detected from sensor 1 DHT22 at 14.00, the humidity is 91% detected from sensor 1 DHT22 at 22.00.

On the third day, the weather conditions on the third day were rainy in the morning, cloudy in the morning before noon, sunny in the afternoon, sunny in the afternoon before evening, sunny in the afternoon, and sunny at night. Based on observations on the graph, the highest temperature is 29.8°C at 15.00, humidity is 75.2% at 15.00. Based on the database on ThingSpeak, the lowest temperature value is 25.7°C detected from sensor 3 DHT22 at 05.00, the highest temperature value is 29.9°C detected from sensor 1 DHT22 at 11.00. A humidity is 71.2% detected from sensor 3 DHT22 at 15.00, the humidity is 90.3% detected from sensor 1 DHT22 at 06.00.

On the fourth day, the weather conditions on the fourth day are sunny in the morning until late in the afternoon, cloudy in the afternoon, and sunny at night. Based on observations on the graph, the highest temperature is 29.9°C at 13.00, 14.00, 15.00, and 16.00, humidity is 73.4% at 13.00. Based on the database on ThingSpeak, the lowest temperature value is 25.8°C detected from sensor 3 DHT22 at 06.00, the highest temperature value is 30.1°C detected from sensor 2 DHT22 at 13.00. A humidity is 68.5% detected from sensor 3 DHT22 at 13.00, the humidity is 89% detected from sensor 1 DHT22 at 23.00.

On the fifth day, the weather conditions on the fifth-day were rainy in the morning, cloudy in the morning before noon, and sunny in the afternoon until the evening. Based on observations on the graph, the highest temperature is 29.3°C at 15.00 and 16.00, humidity is 74.1% at 15.00. Based on the database on ThingSpeak, the lowest temperature value is 26.4°C detected from sensor 3 DHT22 at 03.00, the highest temperature value is 29.4°C detected from sensor 1 DHT22 at 15.00. A humidity is 69.8% detected from sensor 3 DHT22 at 16.00, the humidity is 91.3% detected from sensor 1 DHT22 at 08.00.

On the sixth day, the weather conditions on the sixth day are rainy in the morning, cloudy in the morning before noon, and sunny in the afternoon until the evening. Based on observations on the graph, the highest temperature is 29.6°C at 15.00 and 16.00, humidity is 74.1% at 15.00. Based on the database on ThingSpeak, the lowest temperature value is 26.2°C detected from sensor 3 DHT22 at 08.00, the highest temperature value is 29.9°C detected from sensor 1 DHT22 at 16.00. A humidity is 69.8% detected from sensor 3 DHT22 at 16.00, the humidity is 92.1% detected from sensor 1 DHT22 at 08.00.

On the seventh day, the weather conditions on the seventh day are sunny in the morning until the evening. Based on observations on the graph, the highest temperature is 30.9°C at 16.00, humidity is 62.5% at 16.00. Based on the database on ThingSpeak, the lowest temperature value is 25.9°C detected from sensor 3 DHT22 at 06.00, the highest temperature value is 31.1°C detected from sensor 1 DHT22 at 16.00. Humidity is 60% detected from sensor 3 DHT22 at 16.00, the humidity is 90.7% detected from sensor 1 DHT22 at 05.00.

On the eighth day, the weather conditions on the eighth day are cloudy in the morning, and sunny in the morning before noon until the evening. Based on observations on the graph, the highest temperature is 29.5°C at 12.00, humidity is 74.9% at 09.00. Based on the database on ThingSpeak, the lowest temperature value is 26°C detected from sensor 3 DHT22 at 05.00, the highest temperature value is 30°C detected from sensor 2 DHT22 at 13.00. The humidity is 72% detected from sensor 3 DHT22 at 09.00, the humidity is 88.3% detected from sensor 1 DHT22 at 22.00.

On the ninth day, the weather conditions on the ninth day are sunny in the morning until late in the afternoon, cloudy in the afternoon until late in the afternoon, and sunny in the afternoon until late at night. Based on observations on the graph, the highest temperature is 29°C at 12.00, humidity is 70.1% at 15.00. Based on the database on ThingSpeak, the lowest temperature value is 25.2°C detected from sensor 3 DHT22 at 06.00, the highest temperature value is 29.2°C detected from sensor 1 DHT22 at 12.00. A humidity is 66.4% detected from sensor 3 DHT22 at 15.00, the humidity is 88.7% detected from sensor 1 DHT22 at 22.00.

On the tenth day, the weather conditions on the tenth day are sunny in the morning until the evening. Based on graphic observations, the highest temperature is 30.6°C at 12.00, humidity is 75.3% at 12.00. Based on the database on ThingSpeak, the lowest temperature value is 25°C detected from sensor 3 DHT22 at 06.00, the highest temperature value is 30.8°C detected from sensor 1 DHT22 at 12.00. The humidity is 72.8% which is detected from sensor 2 DHT22 at 12.00, the humidity is 90.1% which is detected from sensor 3 DHT22 at 00.00.

On the eleventh day, the weather conditions on the eleventh day were cloudy in the morning, and sunny in the morning before noon until the evening. Based on observations on the graph, the highest temperature is 30.7°C at 12.00 and 14.00, humidity is 71.8% at 12.00. Based on the database on ThingSpeak, the lowest temperature value is 25.4°C detected from sensor 3 DHT22 at 06.00, the highest temperature value is 30.9°C detected from sensor 3 DHT22 at 14.00. A humidity is 68.2% detected from sensor 3 DHT22 at 14.00, the humidity is 89.7% detected from sensor 1 DHT22 at 07.00.

On the twelfth day, the weather conditions on the twelfth day are sunny from morning to night. Based on observations on the graph, the highest temperature is 30.5°C at 11.00, humidity is 73.5% at 11.00. Based on the database on ThingSpeak, the lowest temperature value is 26.2°C detected from sensor 3 DHT22 at 05.00, the highest temperature value is 28.43°C detected from sensor 1 DHT22 at 13.00. A humidity is 80.1% detected from sensor 2 DHT22 at 16.00, the humidity is 87.4% detected from sensor 3 DHT22 at 04.00.

On the thirteenth day, the weather conditions on the thirteenth day were cloudy in the morning, and sunny in the early afternoon until late at night. Based on observations on the graph, the highest temperature is 30.5°C at 13.00, humidity is 70.6% at 16.00. Based on the database on ThingSpeak, the lowest temperature value is 25.7°C detected from sensor 3 DHT22 at 06.00, the highest temperature value is 30.9°C detected from sensor 1 DHT22 at 14.00. A humidity is 69.3% detected from sensor 3 DHT22 at 16.00, the humidity is 90.8% detected from sensor 1 DHT22 at 06.00.

On the fourteenth day, the weather conditions on the fourteenth day are sunny in the morning until the evening. Based on observations on the graph, the highest temperature is 30.6°C at 15.00, humidity is 70.2% at 15.00. Based on the database on ThingSpeak, the lowest temperature value is 25.8°C detected from sensor 3 DHT22 at 06.00, the highest temperature value is 31.9°C detected from sensor 2 DHT22 at 11.00. A humidity is 65.6% detected from sensor 3 DHT22 at 15.00, the humidity is 90.6% detected from sensor 1 DHT22 at 23.00.

Based on the results of observations on the oyster mushroom house for 14 days, in rainy weather conditions almost all day as on the first day, the temperature and humidity are in the range needed to grow oyster mushrooms. However, in sunny conditions throughout the day, the temperature and humidity are outside the range required to grow oyster mushrooms even though they are misted or sprayed 3-to 4 times. At night starting at 19.00 until the morning at 08.00 the temperature and humidity are in the range required for growing oyster mushrooms, namely 26°C-30°C for temperature and 80%-90% for humidity. However, the humidity is the most difficult to control compared to the temperature value when misting or spraying 3-4 times in sunny weather conditions during the day. This can lead to less than optimal growth of oyster mushrooms. Based on observations for 14 days, the highest temperature detected in the oyster mushroom house was 31.9°C, while the lowest temperature detected in the oyster mushroom house was 24.6°C. humidity lowest humidity detected was 92.3%.

CONCLUSION

In this research monitoring temperature and humidity is based on the internet of things. Based on the results of the research conducted, the following conclusions can be drawn:

1) The based Internet of Things- in this study can run well to monitor temperature and humidity in the oyster mushroom house.
2) The IoT platform used, namely ThingSpeak on the website and the ThingView application on smartphones can run well by displaying temperature and humidity data in real-time.
3) Based on observations for 14 days, the highest temperature detected in the oyster mushroom house was 31.9°C and the lowest humidity detected was 60%.
4) Functionally the detection system from the sensor on the oyster mushroom house can work well.

REFERENCES

[1] Widodo, C. S. Prabowo, S. Winanti and R. E. Juwanto, “Rancang Bangun Sistem Penyiraman Tiram Secara Otomatis Menggunakan Sensor Suhu Berbasis Mikrokontroler Atmega8,” Jurnal Riset Daerah, 2013.

[2] Mahari, Wan Adibah Wan, et al. ”A review on valorization of oyster mushroom and waste generated in the mushroom cultivation industry,” Journal of hazardous materials, 2020.

[3] P. Utama, D. Suhendar and L. H. Romalia, ”Penggunaan Berbagai Macam Media Tumbuh Dalam Pembuatan Bibit Induk Jamur Tiram Putih (Pleurotus ostreatus),” Agroteknologi, vol. 5, pp. 45-53, Juli 2013.

[4] Direktorat Budidaya Tanaman Sayuran dan Biofarmaka, “Standar Operasional Prosedur (SOP) Budidaya Jamur Tiram,” Jakarta. 2010.

[5] G. H. Wangrimen, “Pengaruh Intensitas Cahaya dan Nutrisi Terhadap Pertumbuhan Miselium Pleurotus ostreatus di Tangerang,”. Biogenesis, Vol 5, No. 2, pp. 93-98. 2017.

[6] Al Hamam, Baihaqqi, “Rancang Bangun Sistem Kontrol Dan Monitoring Ruang Budidaya Jamur Tiram Berbasis Multidrop Point Rs485,” PENS, Surabaya, Indonesia. 2013.

[7] Keoh, S. L., S. S. Kumar, and H. Tschofenig, “Securing the Internet of Things: A Standardization Perspective,” IEEE Internet Things J., Vol. 1, No. 3, pp. 265–275, 2014.

[8] S. M. Zinnuraain, M. Hasan, M. A. Hakque, and M. M. N. Arefin, “Smart gas leakage detection with monitoring and automatic safety system,” 2019 Int. Conf. Wirel. Commun. Signal Process. Networking, WiSPNET 2019, pp. 406–409, 2019.

[9] Afrizal, M.A., “Rancang Bangun Rumah Pintar Berbasis IOT (Internet Of Things) Sebagai Media Pembelajaran pada Mata Pelajaran pemrograman, Mikroprosesor dan Mikrokontroller di SMKN2 Surabaya,” Jurnal Pendidikan Teknik Elektro. Vol.7, No.1, pp.79-86, 2018.

[10] Stankovic, J. A., “Research directions for the Internet of Things,” IEEE Internet Things J., Vol. 1, No. 1, pp. 3–9, 2014.

[11] Ridho, S., “Alat Penetas Telur Otomatis Berbasis Mikrokontroler,” Teknik Elektronika Fakultas Teknik Universitas Negeri Yogyakarta, 2019.

[12] A. Akhtar, T. Ahmad, N. Sabahat, and S. Minhas, “IoT based home automation system using thingspeak,” Proc. - 2019 Int. Conf. Comput. Electron. Commun. Eng. iCCECE 2019, pp. 163–168, 2019.
[13] Jamalga Kurniawan, “Rancang Bangun Smartgrowing Jamur Tiram Berdasarkan Kontrol Suhu Dan Kelembapan Berbasis Android,” Pendidikan Teknik Elektro. Universitas Negeri Semarang. 2019.
[14] G. Randa, “Pengaruh Frekuensi Penyiraman Terhadap Pertumbuhan dan Hasil Jamur Tiram Pada Media Serbuk Gergaji,” Jurnal Sains Mahasiswa Pertanian, Vol. 9, No. 2, 2020.
[15] A. M. Rohim, “Rancang Bangun Alat Pendeteksi Suhu dan Kelembapan Berbasis NodeMCU Pada Budidaya Jamur Tiram,” Phenomenon, Vol. 9, No. 2, pp. 219-231, 2019.
[16] Arafat, “Sistem Pengendalian Suhu dan Kelembapan Kumbung Jamur Tiram Secara Realtime Menggunakan ESP8266,” Jurnal Fisika FLUX, pp. 6-12, 2019.
[17] H. Fitriawan, ”Pengendalian Suhu Dan Kelembaban Pada Budidaya Jamur Tiram Berbasis IoT,” Jurnal Teknik Pertanian Lampung, vol. 9, pp. 28-37, 2020.